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Interim Report on the Cost-Effectiveness Analysis of Road Weather Information Systems and Enhancement Project

Ontario

Ministry of Transportation

Research and Development Branch

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Interim Report on the Cost-Effectiveness Analysis of Road Weather Information Systems and Enhancement Project

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Abstract	The MTO has developed a Telidon-based enhancement to its Road Weather Information System (RWIS). This new system supplements existing off-line communications with video display terminals to provide timelier and more accurate weather information to Ministry road maintenance crews. The graphical displays are intended to improve maintenenace decisions and, in turn, reduce the consumption of Mnistry resources in winter maintenance and the adverse effects of the environment. The major objective of the project reported herein was to develop estimates of the cost-effectiveness of the enhanced RWIS. In addition, a small amount of exploratory work with the cost-effectiveness framework would examine the impact of different geographical distributions of terminals, and of different levels of precision in RWIS information on the efficiency of maintenance operations.
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Interim Report

on the

Cost Effectiveness Analysis
of
Road Weather Information Systems
and
Enhancement
Project

Submitted to:

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Research & Development Branch
Ontario Ministry of Transportation and Communication
Downsview

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IDON Corporation
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EXECUTIVE SUMMARY

The Ministry of Transportation Ontario has developed a Telidon based enhancement to its Road Weather Information System (RWIS). This new system supplements existing off-line communications with video display terminals to provide timelier and more accurate weather information to Ministry road maintenance crews.

The graphical displays are intended to improve maintenance decisions, and in turn, reduce the consumption of Ministry resources in winter maintenance and the adverse effects on the environment.

The major objective of the project reported here was to develop estimates of the cost-effectiveness of the enhanced RWIS. In addition, a small amount of exploratory work with the cost-effectiveness framework would examine the impact of different geographical distributions of terminals, and of different levels of precision in RWIS information, on the efficiency of maintenance operations.

It is the first, and major, objective which has been addressed by the project so far.

The Full Experimental Approach Versus The Interim Approach

The Full Experimental Approach

Originally, a full "experimental" procedure was planned, comparing resource utilization (observed in the field) before and after enhancement of RWIS. But when it became clear by March 1987, soon after IDON was commissioned to do this study, that winter storms, and therefore "after" data, would not be forthcoming, an interim procedure was developed to provide a surrogate for this data.

The Interim Approach

The interim procedure was substituted as a method of getting early indications of the cost-effectiveness of RWIS in the absence of real "after" data, i.e.. winter storm data collected expressly for this purpose. The option of implementing the full experimental approach, at the earliest opportunity in the winter of 87/88, would remain open, as a means of arriving at greater levels of confidence in the final conclusions of this study.

The major feature of the interim approach would be a surrogate for "after" data developed by asking Ministry experts to estimate improvements (over pre-enhancement consumption levels) that they would expect with the enhanced RWIS.

Findings From the Interim Approach

The major finding of the interim analysis was that while savings were really apparent, they could not be confirmed in the case of every resource on which data were retrieved from historical records.

The basic difficulty was that the intuitively obvious hypothesis - that the worse the weather and road conditions, the more materials, labour and equipment the Ministry would use for road clearing operations - could not be confirmed for all resources on the basis of the historical data retrieved for this project.

Quantifiable Versus Non-Quantifiable Benefits

The analysis in this project was based on quantifiable benefits - material, equipment and labour costs. It was realised that there were additional important benefits such as comfort and convenience, to Ministry maintenance staff, and to the driving public, which could not confidently be quantified within the scope of the project, and which were therefore not incorporated into the analysis.

These additional benefits must be borne in mind, in favour of RWIS, whenever quantitative results are presented.

The Full Winter Storm Experiment and The Final Project Report

At the earliest opportunity in the 87/88 winter, the present analysis will be augmented to include some 40 "events" developed from individual patrol responses to at least 4 storms in districts where RWIS is being utilized and can therefore be assessed. This exercise will provide the Ministry with increased levels of confidence in the positive but not conclusive indications, developed so far, of benefits to be derived from the enhanced RWIS.

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1

INTRODUCTION

To maintain Ontario's roads during the winter, Ministry maintenance staff must have reliable, easily assimilated information about weather and road conditions. A communication system providing such information has been in place for many years. Centred at Ministry headquarters at Downsview, it used to relay weather and road condition reports, from Environment Canada and Ministry patrols respectively, to each District office.

In 1985 the Ministry introduced an on-line road weather information system (RWIS). This system uses video terminals to display road and weather information in both text and graphic formats. Initially, nine terminals were installed at six sites. Subsequently, six more terminals were installed at six additional sites. Appendix A provides details on the location of these fifteen terminals.

Ministry officials expected that the better quality data from the enhanced RWIS would contribute to improved decision-making and, in turn, to improved efficiency in the allocation of resources.

This study was intended to verify these expectations.

Objectives Of The Study

The major objective of this study was:

- To develop estimates of the relative cost-effectiveness of the Telidon-based road weather information system over the conventional system.

In addition, a small amount of exploratory work would address the following two objectives, using the cost-effectiveness framework:

- To estimate possible impacts on maintenance operations of changes in the information system (e.g. spatial distribution of terminals).

- To explore the question of whether, and by how much, cost-effectiveness might be enhanced by increased precision in the input data to RWIS.

The Full Experimental Approach Versus The Interim Approach

Originally, a full experimental procedure was intended, comparing resource utilization "before" and "after" the Telidon-based system was implemented. "Before" data, i.e. measures of resource consumption based on the previous technology, would be obtained from re-constituted historical data. "After" data, i.e.. measures of resource consumption resulting from decisions based on the new RWIS, would be collected immediately after actual winter storms, using a proper experimental design.

Since storm by storm comparisons could not be set up in a controlled experimental setting, each of these two levels of resource consumption would be summarised as statistical trends. The (anticipated) improvement in resource consumption between the summarised "before" and "after" consumption trends would be taken as the "benefit" attributable to the enhancement of RWIS.

But when it became clear by March 1987, soon after IDON was commissioned to do this study, that winter storms, and therefore "after" data, would not be forthcoming, an interim procedure was developed to provide a surrogate for this data.

The Interim Approach

The interim procedure was substituted as a method of estimating the cost-effectiveness of RWIS in the absence of real" after" data, i.e. winter storm data collected expressly for this purpose.

According to this procedure "before" data would be reconstituted as in the full experimental approach described above. For "after" data, however, a surrogate would be developed by asking Ministry experts to estimate improvements (over pre-enhancement consumption levels) that they would expect with the enhanced RWIS.

Risk with the Interim Approach - Verifying the "Obvious" Weather/Maintenance-Dollar Relationship

The risk with the interim approach, seen to be very small at the time, was that the analysis was based on the development of a statistical relationship between resources consumed in winter maintenance on the one hand, and weather and road conditions on the other. In particular, it was taken for granted that the intuitively obvious hypothesis - that the worse the weather and road conditions, the more materials, labour and equipment the Ministry would use for road clearing operations - could be confirmed for all resources on the basis of historical data retrieved for this project.

It was decided to proceed with the interim approach, and later - in the winter of 87/88 - with the full experimental design, using data taken during and after storms.

Findings From The Interim Approach

The major finding of the interim analysis was that while savings were clearly apparent, they could not be confirmed in the case of every resource on which data were retrieved from historical records. The basic difficulty was that the intuitively obvious hypothesis - that the worse the weather and road conditions, the more materials, labour and equipment the Ministry would use for road clearing operations - could be confirmed for some, but not all, resources on the basis of the historical data retrieved for this project.

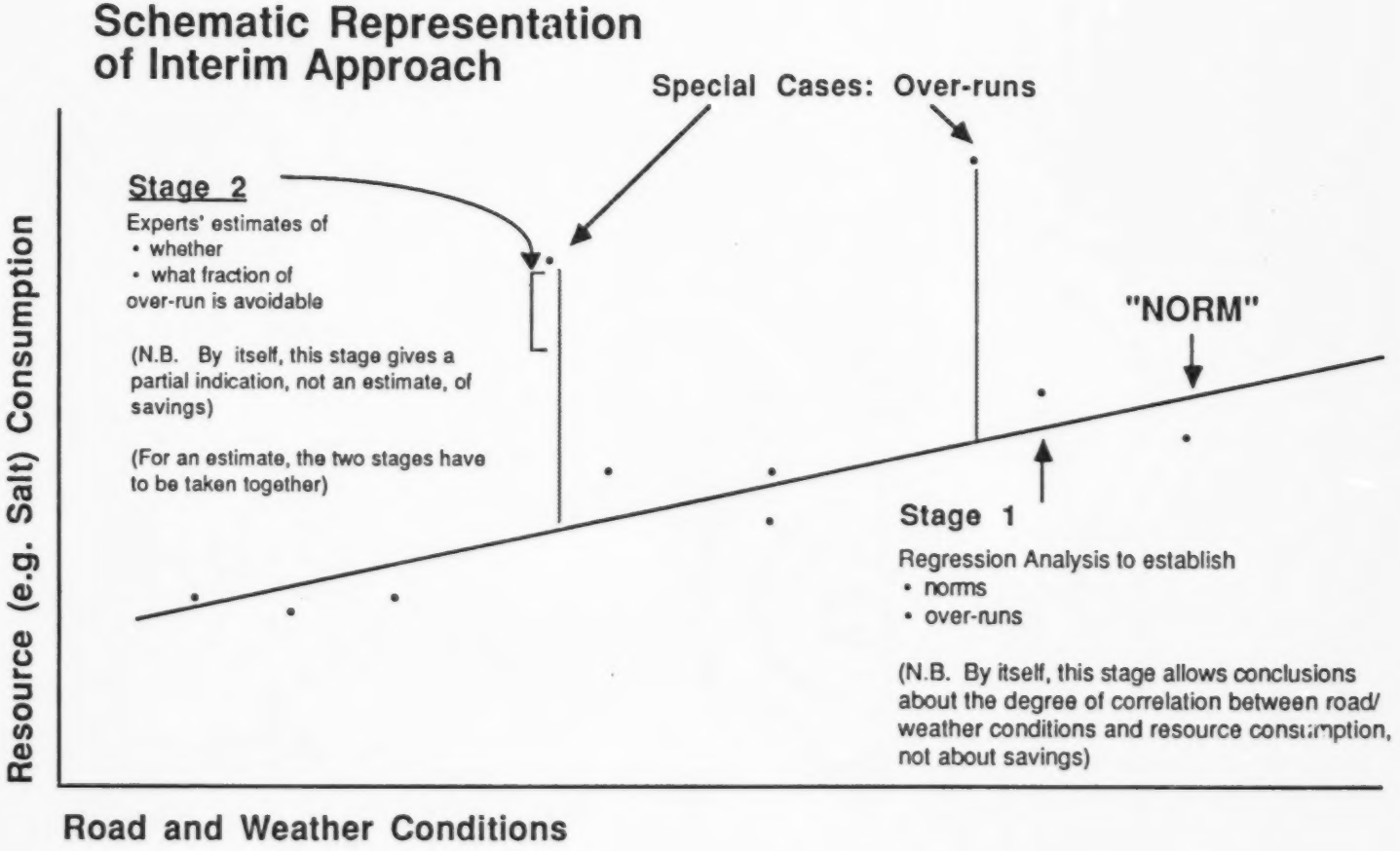
Quantifiable Versus Non-Quantifiable Benefits

The analysis in this report was based on quantifiable benefits - material, equipment and labour costs. It was realised that there were additional important benefits, such as comfort and convenience, to Ministry maintenance staff and to the driving public, which could not confidently be quantified within the scope of the project, and which were therefore not incorporated into the analysis.

These additional benefits must be borne in mind, in favour of RWIS, whenever quantitative results are presented.

The Full Winter Storm Experiment and The Final Project Report

At the earliest opportunity in the 87/88 winter, the present analysis will be augmented to include some 40 "events" developed from individual patrol responses to at least 4 storms in districts where RWIS is utilized and can therefore be assessed. This framework, developed from real data, will be used to explore "what if" and "what's best" questions such as warrants for, and spatial distribution of, terminals, and the additional benefits that might be realisable from precise information.


Schematic Representation of Interim Approach
Special Cases: Over-runs
Stage 2
Experts' estimates of
• whether
• what fraction of over-run is avoidable
(N.B. By itself, this stage gives a partial indication, not an estimate, of savings)
(For an estimate, the two stages have to be taken together)
"NORM"
Stage 1
Regression Analysis to establish
• norms
• over-runs
(N.B. By itself, this stage allows conclusions about the degree of correlation between road/ weather conditions and resource consumption, not about savings)
Resource (e.g. Salt) Consumption
Road and Weather Conditions

II

IMPLEMENTING THE INTERIM APPROACH IN DETAIL

The major question to be answered in this study was the following:

Could maintenance costs be reduced if information from RWIS were used in making decisions before or during winter storms?

Originally, to answer this question, a full experimental procedure was planned, comparing resource utilization (observed in the field) before and after enhancement of RWIS. But when it became clear by March 1987, soon after IDON was commissioned to do this study, that winter storms, and therefore "post-RWIS enhancement" data, would not be forthcoming, an interim procedure was developed to provide a surrogate for the full experimental procedure.

The procedure consisted of two stages, described below.

Stage 1: Statistical Analysis to Estimate "Norms" - and "Over-Runs" in Ministry Maintenance Expenditures

Assumptions Underlying "Norms" and "Over-runs"

It was assumed that Ministry maintenance staff normally achieved near optimum economy in resource expenditure, but that for a relatively small number of winter storms, some patrols experienced "over-runs", i.e. unusually high levels of resource expenditure which could not be explained by bad weather and road conditions. A further starting assumption was that in these incidents in which the economies realised were well below normal, patrol personnel were nevertheless making rational decisions based on the information at their disposal.

It remained, in accordance with these assumptions, to estimate norms of Ministry maintenance expenditures, to identify over-runs, and to solicit Ministry expert opinion on whether, and to what extent, information such as that available from the enhanced RWIS system could have reduced the over-runs.

Data Collection - Resource Consumption and Weather

From Ministry records (logs of daily activity) historical data were retrieved on five resources consumed in winter maintenance operations: Salt, Sand, Ministry Labour, Contract Labour, and Ministry Equipment Use. Fifty-nine separate winter maintenance actions by nine patrols in the two Ministry districts of Toronto (District 6) and Ottawa (District 9) were reviewed. The highways on which these actions were carried out ranged from two-lane rural highways to Highway 401 through Toronto. The data represented events occurring on thirteen calendar dates.

In addition, detailed historical weather information for these thirteen dates was retrieved.

Regression Analysis

Regression analysis was used to seek explanations of, and establish norms for, the five categories of expenditure (Salt, Sand, Ministry Labour, Contract Labour and Ministry Equipment) costs in terms of weather and road conditions. These equations were developed to identify which environmental conditions best explained a particular category of expenditure. Appendix C provides more details on the regression analysis.

Stage 2: Applying Expert Opinion to Statistical Estimates

Instances of expenditure over the norm were identified, and expert opinion was solicited - by questionnaire - to estimate the proportion of the over-run that might have been avoided with improved information.

The Questionnaire

A survey questionnaire (See Appendix E) was developed, tested, and approved by the MTC Project Steering Committee. The questionnaire was addressed primarily to those who had used RWIS in the past, but others were encouraged to make educated "guesstimates" of the savings. The last segment of the questionnaire solicited general opinions on RWIS.

The questionnaire was distributed to seventeen Ministry staff in nine locations: Bancroft, Burlington, Chatham, Downsview, Kenora, Kingston, London, Ottawa and Toronto. Eight patrol staff, seven district engineers, one radio room staff member and one member of the Public and Safety Information Branch were the recipients in those nine locations.

III

INTERIM FINDINGS

The major interim indication is that economic savings can be realised through use of RWIS even though this could be demonstrated confidently in the case of only two of the five resources which were analysed, somewhat less confidently in the case of a third resource, and not at all in the case of a fourth and a fifth. These findings are given in more detail below.

Regression Analysis

The regression analysis explored the correlation between historical data on expenditures and road and weather conditions. The basic relationship sought was the intuitively obvious one - that the worse the weather and road conditions, the more materials, labour and equipment the Ministry would use for road clearing operations. Surprisingly, and at some cost to the overall analysis, this basic relationship was not borne out in the case of every resource consumed in winter maintenance.

Relatively strong relationships ($R^2 > .50$) were found between contract labour and weather conditions and between contract vehicle usage and weather conditions, each of these results being based on more than 50 observations. One regression run with data on salt usage gave a strong relationship with weather conditions ($R^2 > .75$), but this run was based on only 8 observations. On the other hand Ministry labour and Ministry vehicle usage showed particularly poor correlation with road and weather conditions.

Cost to the Rest of the Analysis

The final estimates of benefits, incorporating the survey of experts, was intended to be built on the "obvious" relationship of greater costs for worse road and weather conditions. Since this latter relationship could not be demonstrated in the case of every resource, we have only a good indication, i.e. not proof, that savings may be realised with information from the enhanced RWIS.

The Expert Opinion Survey

The expert opinion survey, on balance, generated positive statements about the economies realisable with RWIS. Respondents who had used RWIS in the past claimed to have made better decisions as a result. Those who had not used RWIS but were asked to predict whether there were likely benefits, predicted such benefits.

SUMMARY OF REGRESSION RUNS

Category of Expenditure	Number of Observ.'s	Road and weather condition parameters with which correlation sought								Level of Explanation Achieved R^2
		Storm Duration (.5HR)	Average Temp	Temp Fluct'n	PPT'TION Type	Average Wind Velocity	Time to next Storm	Amount of PPT'TION	Number of Lanes	
Salt tonnage	8	√	√	√	√	√	√	√		0.75
Salt tonnage	58	√				√	√			0.25
MTC labour (hours)	57	√				√		√		0.21
Contractors' labour (hours)	59	√				√			√	0.61
MTC vehicle (hours)	59	√	√			√		√		0.27
Contractors' vehicle hours	59	√				√				0.57

Final Comments - Likely Sources of the Difficulty Experienced

Because the correlations obtained were not uniformly strong for all categories of expenditures, the potential savings could not be quantified with confidence for all resources. Appendix E outlines the form of the calculations that would have been done for all resources if the correlations could have been established.

It is possible to speculate on possible reasons for the failure to establish the "intuitively obvious" relationship between weather and road conditions on the one hand, and maintenance expenditures on the other:

1. Since the data were retrieved from diverse Ministry records, it is possible that some specific weather observations could not be properly matched with specific maintenance actions.

2. A summary table of raw data retrieved from Ministry records reveals elementary inconsistencies which could have been investigated in greater depth before being put through regression analysis. Imperfect results might have been predicted, had more time been spent analysing this data.

3. The possibility must be entertained that Ministry expenditures are at variance with the "objective" conditions in the environment - i.e. the general rule of the worse the road and weather conditions, the greater the expenditure on winter maintenance, may simply not hold.

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Appendix A: Terminal Locations

1985/86 Winter Season

Number of Terminals	Location
2	District 9 Office, Ottawa
1	District 10 Office, Bancroft
1	District 8 Office, Kingston
1	Regional Municipality of York, Newmarket
1	District 6 Office, Willowdale
3	MTC, Downsview

1986/87 Winter Season

Number of Terminals	Location
4	District 6 Patrols
1	MTC Public & Safety Office, Toronto
1	Ontario Provincial Police, Toronto

Totals

1985/86 Winter Season	9 terminals	6 sites
1986/87 Winter Season	6 terminals	6 new sites
Totals	15 terminals	at 12 sites

Appendix B: Steering Committee Members

Ministry of Transportation and Communication

A. Bacchus,	Research Engineer, Traffic and Decision Systems Office, Research and Development Branch, Highway Engineering Division
Jeff Bond,	Senior Communications Specialist, Operations and Technology Office, Communications Division
R.P. Bulger,	Manager, Operations and Technology Office, Communications Division
E.R. Case,	Principal Research Engineer, Traffic and Decision Systems Office, Research and Development Branch, Highway Engineering Division
H. K. Kirchner,	Manager, Maintenance Operations Office, Maintenance Branch, Highway Operations and Maintenance Division, **Chair**

APPENDIX C:
Exploring Relationship Between Weather Conditions and Ministry Expenditures - By Regression Analysis

The logic of Ministry maintenance decision-making may be represented as follows:

Event Occurs ----------> **Information Gathered** ----------> **Actions Taken**

Process A Process B

Process A represents the conversion of information on natural events into RWIS data. RWIS is a tool enabling the Ministry to gather information and present it in a format usable by Ministry maintenance staff.

Process B represents the decision-making function which we wish to estimate quantitatively, using regression analysis. The regression equations to be developed do not attempt, by themselves, to prescribe how resources should optimally be spent. They seek explanations of the variation in expenditures based on environmental conditions.

Such explanations were sought for five categories of expenditure:

i) tonnage of salt used
ii) tonnage of sand used
iii) Ministry labour costs (stand-by time and clean-up after storm).
iv) Contractor labour costs (as above)
v) Ministry equipment cost

The following eight measures of road and weather conditions were identified as having the greatest potential influence on maintenance expenditures. Units are given:

i) storm duration - X1, say (in 0.5hr units)
ii) average temperature during storm - X2°C
iii) temperature fluctuations during storm - X3°C
iv) precipitation type - X4 (rain, snow, sleet, etc.)
v) average wind velocity - X5 (km per hour)
vi) time to next storm - X6 (in 0.5hr units)
vii) amount of precipitation - X7 (cm)
viii) number of lanes worked on: majority of action - X8

Outputs of the regression procedures are of the form

Maintenance Expenditure = a0+
a1 x X1+
a2 x X2+
a3 x X3+
a4 x X4+
a5 x X5+
a6 x X6+
a7 x X7+
a8 x X8+

where a0.. ...a8 are coefficients estimated by the regression procedure.

The objective of this part of the analysis is to find 5 such regression equations, one for each category of maintenance expenditure.

Once an equation is fitted to the data, we can identify expenditures which exceed the norm. The amount of each such over-run is the upper bound on savings that might be obtained by all likely means. The Delphi survey of experts will then be used to estimate the proportion of these potential savings that is realisable through use of RWIS.

Appendix D: Expert Opinion Survey

Note: **This letter, appropriately addressed, accompanied the enclosed survey.**

MTC is constantly attempting to improve its information system so that better decisions can be made.

The Road Weather Information System (RWIS) is one such system.

We have been contracted by MTC's Research and Development Branch to obtain opinions about RWIS from a select number of MTC staff.

This questionnaire should take less than 5 minutes to complete.

Your input is important in determining the future of RWIS.

We would appreciate it very much if you would please return the completed questionnaire promptly. A stamped pre-addressed envelope is enclosed.

If you have questions please contact Mr. Ataur Bacchus of MTC at 416-235-4673, or myself at 613-722-8101.

Thank you in advance for responding to this request.

Sincerely,

James Feeley
Principal
IDON Corporation

Q1 **Did you have access to RWIS during past winters?**

Yes — If Yes please proceed to Q2.

No — If No please proceed to Q12.

Q2 **Did RWIS help you make better decisions?**

Yes — If Yes please proceed to Q3.

No — If No please proceed to Q12.

Q3 **By how much did road conditions improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q4 **By how much did the quality of information available to the public improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q5 **By how much did the scheduling of tasks improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q6 **By how much did other activities improve?**

(Please indicate type of activity and %age of improvement)

Q7 **By how much did salt usage decrease?**

0% 5% 10% 15% 20% 25% 30%

Q8 **By how much did sand usage decrease?**

0% 5% 10% 15% 20% 25% 30%

0% 5% 10% 15% 20% 25% 30%

Q9 **By how much did road patrol time decrease?**

0% 5% 10% 15% 20% 25% 30%

Section 2 The Future

Q12 **In you opinion if, in the future, RWIS is incorporated into MTC's operations will it help you make better decisions?**

Yes
If Yes proceed to Q13.

No
If No proceed to Q22.

Q13 **By how much do you think road conditions will improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q14 **By how much do you think the quality of information available to the public will improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q15 **By how much do you think the scheduling of tasks will improve?**

0% 5% 10% 15% 20% 25% 30% more than 30%

Q16 **By how much do you think other activities will improve?**

Please indicate type of activity and %age of improvement)

Q17 **By how much do you think salt usage will decrease?**

0% 5% 10% 15% 20% 25% 30%

Q18 **By how much do you think sand usage will decrease?**

0% 5% 10% 15% 20% 25% 30%

Q19 **By how much do you think road patrol time will decrease?**

0% 5% 10% 15% 20% 25% 30%

Section 3 : **Storms**

This section is for Patrol Supervisors.

Q22 **In your opinion on the average how many winter storms are there**

in November?	0	1	2	3	4	5	6	7	8	9	10
in December?	0	1	2	3	4	5	6	7	8	9	10
in January?	0	1	2	3	4	5	6	7	8	9	10
in February?	0	1	2	3	4	5	6	7	8	9	10
in March?	0	1	2	3	4	5	6	7	8	9	10

Q23 **In your opinion in how many of those winter storms do you think RWIS could be used to help you make better decisions?**

November	0	1	2	3	4	5	6	7	8	9	10
December	0	1	2	3	4	5	6	7	8	9	10
January	0	1	2	3	4	5	6	7	8	9	10
February	0	1	2	3	4	5	6	7	8	9	10
March	0	1	2	3	4	5	6	7	8	9	10

Section 4: **Comments**

This section is for all Respondents.

If you have any comments about the questionnaire and the actual or potential usefulness of RWIS please note them here. Thank you.

Appendix E: Sample Calculation of Savings with Assumed Numbers

This section illustrates how the intended procedure would have been carried out if strong relationships had been found between the several categories of expenditure on the one hand, and road and weather conditions on the other.

Relatively strong relationships ($R^2 > .50$) were found between contract labour and weather conditions, and between contract vehicle usage and weather conditions, each of these results being based on more than 50 observations. The results were not as good with salt usage, ministry labour and ministry vehicle usage.

The sample calculation is given for contractor labour costs:

CONTRACTOR LABOUR COSTS

The basic steps in the methodology are to

i) determine an explanatory equation for Contractor labour.

ii) calculate if the maintenance expenditure of any one event exceeds a specified value.

iii) analyze if over-expenditure was caused by an unusual event. If so, discard from sample, if not continue.

iv) calculate a standardized unit of measure (an example could be hours of Contractor labour) that represents the size of the over-expenditure.

v) determine the cost of one unit of Contractor labour (for example,$25 per hour).

vi) produce results from Delphi questionnaire that pertains to Contractor Labour (for example, a 10% saving of Contractor labour is expected if RWIS is implemented).

vii) multiply the following:
number of units of over-expenditure **X**
cost of one unit of Contractor Labour **X**
Delphi results concerning Contractor labour.

viii) determine a gross-up factor based on the size of the initial sample size in relation to the total size of potential RWIS users.

This eight step procedure appears numerically as follows:

Step 1

The basic equation for Contractor Labour from our model was:

Hours of Contractor Labour = A + B(Storm Duration)
+ C(Wind Velocity)
+ D(Number of Lanes)

This equation produces an R^2 of .61. In other words only 61 percent of the variation in the contractors' hours is explainable using this model. As stated this is slightly below a useable range. For equations of this type a confidence level of 70% or better is required. However, for illustrative purposes lets assume this equation is usable.

Step 2

From our model results, it was determined that 5 events during the 1986-87 winter fell into the over-expenditure category.

Step 3

None of these events were caused by an unusual event therefore all can be used in the analysis.

Step 4

In contractor hours the standardized units of over-expenditure for each event are;

event 1	179.2 hours
event 2	81.2 hours
event 3	63.1 hours
event 4	88.9 hours
event 5	67.0 hours
Total	479.4 hours

Step 5

Let us assume the fully loaded labour cost of one Contractor hour is $25

Step 6

Let us assume the Delphi Questionnaire stated that it is expected the RWIS system can save 10% a year in Contractor labour costs

Step 7

Multiplying our figures together will produce the expected benefits RWIS will generate for the maintenance variable Contractor labour

Maximum number of Contractor hours to be saved	479.4
Cost of one Contractor hour	25.00
Maximum Benefit Possible	$11985
RWIS Impact Ratio	10%
RWIS Benefit due to Contractor Labour Saving	$ 1199

Step 8

Let us assume our sample size represents one fifth of the total population of patrols. Therefore we must take our RWIS benefit number and gross it up to the entire population of patrols.

RWIS Benefit (from the sample)	$1199
Gross-up factor (to get to universe of potential users)	5.0
Total RWIS Benefit due to savings in Contractor Labour	$5995

As you are well aware the bottom line Benefit calculation depends on a number of variables, the two critical factors , however, are

1) Delphi questionnaire results and
2) The gross-up factor

For example, if we change the Delphi results from 10% to 33% the benefits realizable go from $5995 to $19775.

This entire sub-section of this report was based on a hypothetical example and the numbers that were used were assumed and had little likelihood of approximating an actual example. Therefore, do not view the results in terms of magnitudes as being anything other than for illustrative purposes.

What this sub-section demonstrates is how the methodology would have been applied if Stage 1 of the process had provided meaningful results. This sub-section also points out what we have learned from the study to date, namely, we now know which variables are most important in explaining maintenance activities and the results from the Delphi are positive in terms of helping us determine the potential impact of RWIS.

Appendix F: Response to Expert Opinion Survey

3 pages

Section 1 Past Winters

Q1 Did you have access to RWIS during past winters?

Yes 9 — If Yes please proceed to Q2.

No 4 — If No please proceed to Q12.

Q2 Did RWIS help you make better decisions?

Yes 7 — If Yes please proceed to Q3.

No 2 — If No please proceed to Q12.

Q3 By how much did road conditions improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%	N.R.
	3	**2**			**1**			**1**

Q4 By how much did the quality of information available to the public improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%
1	**1**			**1**	**1**	**1**	**2**

Q5 By how much did the scheduling of tasks improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%
1	**1**	**1**					**4**

Q6 By how much did other activities improve?

(Please indicate type of activity and %age of improvement)

See Appendix G

Q7 By how much did salt usage decrease?

0%	5%	10%	15%	20%	25%	30%	unable to measure
4	**2**						**1**

Q8 By how much did sand usage decrease?

0%	5%	10%	15%	20%	25%	30%	unable to measure
6							**1**

Q9 By how much did standby time for MTC staff decrease?

0%	5%	10%	15%	20%	25%	30%
3	**3**					**1**

Q10 By how much did standby time for contractors decrease?

0%	5%	10%	15%	20%	25%	30%
5		**1**	**1**			

Q11 By how much did road patrol time decrease?

0%	5%	10%	15%	20%	25%	30%
5	**1**				**1**	

Response to Expert Opinion Survey

Section 2 The Future

Q12 In you opinion if, in the future, RWIS is incorporated into MTC's operations will it help you make better decisions?

Yes **8** No **5**

If Yes proceed to Q13. If No proceed to Q22.

Q13 By how much do you think road conditions will improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%	N.R.
	1	**1**		**2**		**1**		**3**

Q14 By how much do you think the quality of information available to the public will improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%	
				2	**1**		**4**	**1**

Q15 By how much do you think the scheduling of tasks will improve?

0%	5%	10%	15%	20%	25%	30%	more than 30%	
	1			**1**	**2**		**2**	**2**

Q16 By how much do you think other activities will improve?

(Please indicate type of activity and %age of improvement)

See Appendix G

Q17 By how much do you think salt usage will decrease?

0%	5%	10%	15%	20%	25%	30%	N.R.
1		**3**	**1**				**3**

Q18 By how much do you think sand usage will decrease?

0%	5%	10%	15%	20%	25%	30%	N.R.
3		**2**					**3**

Q19 By how much do you think standby time for MTC staff will decrease?

0%	5%	10%	15%	20%	25%	30%	N.R.
2		**3**				**1**	**2**

Q20 By how much do you think standby time for contractors will decrease?

0%	5%	10%	15%	20%	25%	30%	N.R.
3		**1**		**2**			**2**

Q21 By how much do you think road patrol time will decrease?

0%	5%	10%	15%	20%	25%	30%	N.R.
1	**1**		**1**	**2**	**1**		**2**

Response to Expert Opinion Survey

Section 3 : Storms

This section is for Patrol Supervisors.

Q22 In your opinion on the average how many winter storms are there

in November?	0	1	2	3	4	5	6	7	8	9	10
in December?	0	1	2	3	4	5	6	7	8	9	10
in January?	0	1	2	3	4	5	6	7	8	9	10
in February?	0	1	2	3	4	5	6	7	8	9	10
in March?	0	1	2	3	4	5	6	7	8	9	10

Q23 In your opinion in how many of those winter storms do you think RWIS could be used to help you make better decisions?

November	0	1	2	3	4	5	6	7	8	9	10
December	0	1	2	3	4	5	6	7	8	9	10
January	0	1	2	3	4	5	6	7	8	9	10
February	0	1	2	3	4	5	6	7	8	9	10
March	0	1	2	3	4	5	6	7	8	9	10

Note: Q22 and Q23 were unclear to respondents hence no meaningful compilation of responses is possible.

Section 4: Comments

This section is for all Respondents.

If you have any comments about the questionnaire and the actual or potential usefulness of RWIS please note them here.

See Appendix G

Appendix G: General Opinion on RWIS from Expert Responses

There were three opportunities for the respondents to make comments when answering the questionnaire. Only a few make comments relating to questions 6 and 16, however ten respondents make comments in Section 4.

Below are the comments extracted from the responses. No editing has occurred. Respondents' comments are separated from each other by the dotted line, thus -----

SECTION 1: **Past Winters**

Q6 **By how much did other activities improve?**
(Please indicate type of activity and %age of improvement)

Advance info re storms/weather 30%+ overtime planning 0-5%

30%

Salting - 25% (time)
Road Maintenance - 15%
Stand-by - 60%-80% (Man Hours)
Pre-storm planning - 10%

Patroling - decreased

SECTION 2: **The Future**

Q16 **By how much do you think other activities will improve?**
(Please indicate type of activity and %age of improvement)

30%

General or routine - 20% or more average

Too early to say! (time will tell)

Section 4: **Comments**

This section is for all Respondents.

If you have any comments about the questionnaire and the actual or potential usefulness of RWIS please note them here. Thank you.

If more districts were using RWIS the public information benefits would increase.

The system is helpful for managers to monitor ongoing operations.

The weather forecasting is not as effective as it should be. The scale of information is too small to pinpoint storm centers etc. with patrol boundaries etc.

When Districts do not have 24 hr. coverage on patrols it does help determining whether staff should remain on during the open shift.

Kingston needs better weather data input. King City radar is too far. Close U.S. weather centres would benefit. Key is communicating info to the field!

We just got our Computer at the yard in March of 87 - but I used the RWIS at the head office when we put the steel up at Brimley Bridge - the info was invaluable to the Contractor & M.T.C.

Decisions are made on what is happening in your area. RWIS covers too large an area to pin point what you are actually going to get in your area.

Could not answer majority of questions since we have no experience and little knowledge of RWIS.

We tend to be relying on the RWIS a great deal as a handy-man's tool. More education of the system can only help if we realize to use common knowledge & practical experience as a good salad.

Sect. 2 the Future Q13-Q18 (Pure Speculation since severity of future winters is unknown).

Q19 & Q20 - Presently no standby time for either MTC. Employees or for contractors' Employees.

Good to view weather forecasts for 24 hour & 36 hour. Road winter operations are controlled by Weather, however, manned patrolman make the decisions. Not a screen monitor.

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1. I doubt that any of the "% questions" in section 1 can be answered with any degree of reliability.

2. Any answers in section 2 will be pure speculation and hardly a basis for decision making.

3. Re section 3, we have yet to find an average month or winter. In any case, how is this question relevant to any decisions.

Note: The questionnaire appears to be of low utility!!

R.W.I.S. is not precise enough. It will not show any percipitation below a 1000 ft.

If RWIS could give us a map of our highways on our patrol we could pin point the storm better. The weather map is too wide spread in general.